CRYSTALLIZATION AND CONVECTION IN COOLING MAGMA CHAMBERS

Geneviève Brandeis

Laboratoire de Dynamique des Systèmes Géologiques
Institut de Physique du Globe de Paris
4, Place Jussieu. 75252 Paris Cedex 05 - France

INTRODUCTION

Rocks that we see at the Earth's surface are crystalline assemblages and some of them result from solidification of a liquid called magma. Undoubtedly, the most spectacular flows of magma in Nature are lava flows that occur over kilometers on the slopes of volcanoes during eruptions (Williams and McBirney, 1979). Although several km^3 are sometimes erupted during an eruption, much larger volumes of lava are stored under volcanoes in reservoirs that are called magma chambers. Such reservoirs are situated at shallow depth (few km) under the Earth surface.

There are several difficulties to overcome for geophysicists that study solidification problems in these liquids. First, very few direct observations can be made on these processes because most chambers are buried deep into the Earth. Second, cooling occurs on very long time-scales compared to the life of a geophysicist. For example, it takes ~1 year to grow a crystal in quasi-equilibrium conditions to its natural size of 1mm. It also takes ~30 years to solidify a 100m thick lava lake (Helz, 1987) that cools at the Earth surface (this is a small chamber that has been formed during a volcanic eruption by filling up a depression). Another specific problem in geophysics is the large dimensions of the object that is studied. For example, the chamber under the Kilauea Volcano (Hawaii) has been inferred to have an horizontal dimension of ten kilometers and a vertical dimension of a few kilometers (Ryan et al, 1981). For all these reasons, there cannot be any direct methods of observations of the solidification processes in geology. Therefore, theoretical models have to be coupled with numerical and fluid dynamical experiments. It should also be mentioned that, in order to understand the cooling of these reservoirs of large dimensions, the problem of solidification is not studied microscopically.

The understanding of the dynamics of magma chambers during solidification is essential to the prediction of volcanic eruptions (Blake, 1984; Tait et al, 1989) and to the interpretation of complex structures observed in fossil magma chambers. These were active magma chambers some millions years ago. They are now completely solidified and erosion has brought them to the Earth's surface, for the great luck of geologists. The study of these reservoirs is also very important as these rocks are often associated with ore deposits such as platinum. For example, the largest platinum deposit of the world is observed in the Bushveld (South

Growth and Form, Edited by M. Ben Amar *et al.*
Plenum Press, New York, 1991